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The Connectivity of Multiport Route Network to Container Loading Planning

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***Abstract* - In determining a container loading plan on board, the goal is to find a container loading plan which considers the structural and operational boundary conditions. In the past, the container loading plan was made by the captain, but now the container terminal has an expert planner to determine the Master Bay Plan. The container loading plan is made in accordance with ship loading instructions with coordinators representing ship owners and cargo owners. The arrangement of containers to be loaded at certain ports into certain slots into the Bay Plan arrangement on the container ships will maximize capacity utilization and minimize operational costs. One important factor in achieving this goal is minimizing overloading – a situation where the containers to be unloaded are blocked by containers destined for the next port. A container loading plan is difficult to make due to several factors: heterogeneity of packages in terms of size, weight, stack ability, position and orientation. The port transshipment pattern plays a unique place in a multiport network design. The transshipment port is the connecting port between the network route section and the feeder. Regular feeder lines connect the hub with several shallow feeder ports located in the same area as the hub port. The containers loaded on feeder vessels at one port are usually transported to more ports of destination. Feeder container route schedules – including the date and time of arrival and departure – must be notified in advance.**

Keywords: Connectivity, Containers, Multiport, Loading Plan, Routes.

I. INTRODUCTION

The pattern of world maritime transportation trade continues to develop in the midst of uncertainty after the COVID-19 pandemic which continues to increase. There are trends in the world economic growth and shifting patterns of globalization, and technological disruption. The Container Fleet will continue to grow by ± 5% until 2024. Indonesia must continue to maintain this positive trend where the trade relations are increasing. The trade and distribution of goods using ships is the most relevant mode of transportation between continents, countries and islands. The ability of ships to transport trade commodities in large quantities allows for lower logistics costs. Although there is an increased economic activity in countries in the Central and Eastern European regions, it remains a container trade route in this situation of economic recovery.

Technological advances in the transportation system are influenced by the development of a country's economy and trade. Economics of Scale and Agglomeration Economics can be grown through the role of transportation. The ease of transportation expands the range of distribution of goods or services. Other effects also support the efficient distribution of industrial production inputs and enable the specialization model of production activities. The container transport system is a combination of various forms of transportation carried out by containers. The use of containers to facilitate the loading and unloading of goods simplifies the system so that it is efficient and effective. However, with today's very large container ships, which require thousands of container movements to load and unload, it is quite difficult to achieve this efficiency[1].A good organization of feeder lines, the purpose of cargo concentration, and a decrease in the frequency of ship departures will result in an increase in the quality of transportation services[2].

A container transportation system integrated with other modes of transportation allows them to be carried out with several modes of transportation. This way, its presence can facilitate multiport route network patterns. Decentralized development and management of port areas, due to their affiliation with different administrative areas, creates problems. The port's interest in developing the local economy has an impact on the port policy. Port infrastructure expansion and loading arrangements in multiport routes are absolutely necessary. The arrangement of container loads for multiports aims to reduce useless container movements as much as possible[3].

Container terminals are the main gateway in the maritime network and they play an important role in the container transportation. Noted by many researchers, the efficiency of

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handling container terminals has a significant influence on freight forwarding operations[4].Optimizing the container handling is becoming increasingly important for the container terminals. Storage of goods at the container terminals is a combinational engineering system consisting of several sub-systems that work together. At the container terminal, the loading and unloading activities for liners are the top priority handling. The results of the study show that in most terminals, the efficiency of container handling is limited by the loading process, and the allocation of loaded containers[5]. Efforts to improve loading efficiency are always a problem in the container handling.

Indonesia is a large country connected by the sea. The most effective and efficient inter-regional trade flows use sea routes for transportation. Approximately, there are 32 ports throughout the region. A port consists of the main port, feeder port,and pioneer port. The size of the area and the number of trading commodities are very likely to arise problems in managing the logistics system. The international trade in Indonesia is served by the main port for as much as two-thirds of the trading activity[6]. This condition has become a factor in the problem of container ship traffic at the Tanjung Priok Port in Jakarta, which has become overwhelmed. The logistics production costs is increasing and inefficient. In Indonesia, the distribution of containers to other ports with multiport conditions requires good and planned arrangements. This study was conducted with the aim of minimizing the total financing of ships caused by demurrage. Multiport routes in Indonesia require good container management to minimize logistics production costs.

II. LITERARURE REVIEW

The containers that will be unloaded and loaded, and then hit by container blocks destined for the next port is such a big problem. Since the stacks are only accessible from above, these containers must be moved to allow the containers below to be moved. The basic Container Loading Problem can be defined as a problem of placing a set of boxes into a container with geometric constraints[7]. The boxes cannot overlap nor exceed the dimensions of the cargo hold. It really implies that a good loading plan fulfills several important aspects. General requirements related to sea level and the use of cranes in ports, and sub-objectives related to the act of stacking and consolidating cargo must be observed.

The container fleet is the second biggest asset of a shipping company after container ships, in terms of capital investment. The containers as equipment have two states in the logistics process, namely loaded containers and empty containers. The loaded containers are often considered as shipments whose routes are determined primarily by the shipper or carrier. Meanwhile, the empty containers are mobile devices for reuse, and their storage and flow especially transportation are determined by the company. In increasing the utilization of container fleets, it is important for shipping companies to manage the distribution of empty containers efficiently[8]. In general, the container logistics covers the following planning topics:

1) Container leasing
2) Storage, transportation, and shipment of loaded containers
3) Relocation of empty containers.

The container storage plans are usually created by shipping company storage planners in a process called storage planning. Stock plans are created manually using graphical tools. However, in recent decades, the shipping industry has faced an increasing demand for containerized shipments. Shipping with multiport must be calculated as well as possible to minimize obstacles. Considering the cargo plans based on cargo and port data, multiport main loading plans, cargo plan 1 and cargo plan 2 to the loading plans is very important[9]. Figure 1 shows the decomposition of the loading plan based on the data.

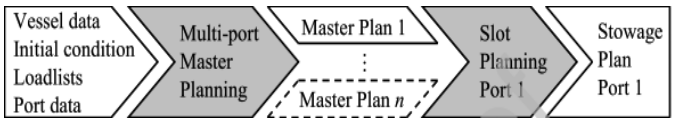

Figure 1: Loading Plan Decomposition

Figure 1 shows that accurate data on ship condition, lists of loading and port data are the main requirements in preparing the loading plan. The loading master plan is the main document for making a more detailed plan. Accuracy and priority of cargo based on the sequence of unloading ports can be used in making a stowage plan. In reduce problems related to container shipping, scheduling shipments can be done. One of the ship scheduling methods for fluctuating price routes is based on reasoning evidence and market balance[10].

2.1 Multiport

The storage of containers on board for single ports and multiple ports requires different planning. The single port storage planning problem only considers creating a storage plan for one port. The multi-port storage planning problem considers the entire ship route to generate storage plans for multiple ports across the route. The container loading planning problem can be easily simplified. Containers of different sizes and weights must be loaded and unloaded at several ports while maintaining the stability of the ship. At the beginning of the process, solving the problems with or without considering the size of the container and the weight of the container, with

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the multi-port container storage planning problem can be done by using mathematical algorithm[11]. Similar actions can also be done with the trend of concentration of container stacking or de-concentration in the process of loading containers with multiple ports. The system from year to year can be managed easily with the relative relationship between plotted points and typical points or lines, namely the ternary diagram method which has shown some significant advantages[12].

2.2 Stowage Plan

A container ship stowage plan is a plan that describes how the cargo will be loaded and stacked on a container ship. This stowage plan is also known as the bay plan. The containers are stored in holds and decks according to field plans. During the cargo operations, it should be ensured that the first unloading container is loaded on the top and the last unloading container is loaded on the bottom. Also, the light containers are on the top and the heavy containers are on the bottom. However, some dangerous cargoes are sensitive to sunlight and need to be stored in the hold, while some dangerous containers need to be stacked on the deck. Some charges react with each other when placed close together. The cargo has to be loaded in different sections. The purpose of the loading planning problem is to minimize the time needed to move the container and minimize the movement of the crane on the journey of the container ship while maintaining the stability of the ship[13].In addition, in the container's Stowage Plan, the development of a constraint programming model for all container loading problems with the Master Bay Plan uses a multi-phase approach to produce a complete and perfect container loading plan [9].

III. RESULTS AND DISCUSSION

Based on the expert analysis, it is estimated that around 90% of world trade is transported by sea, and 40% of them passes through Indonesian waters. Obviously, 40% is an extraordinary number. Indonesia's geographical location is on the equator and is strategically located between the continents of Asia and Australia. The Pacific Ocean lies to the east and northeast of Indonesia and the Indian Ocean to the south. The location of these islands is a maritime traffic link that transports goods from the eastern and western continents. This means that at any time, Indonesia always occupies a strategic position on the world trade map. A port map to support trade and logistics distribution in Indonesia is presented in Figure 2 below.

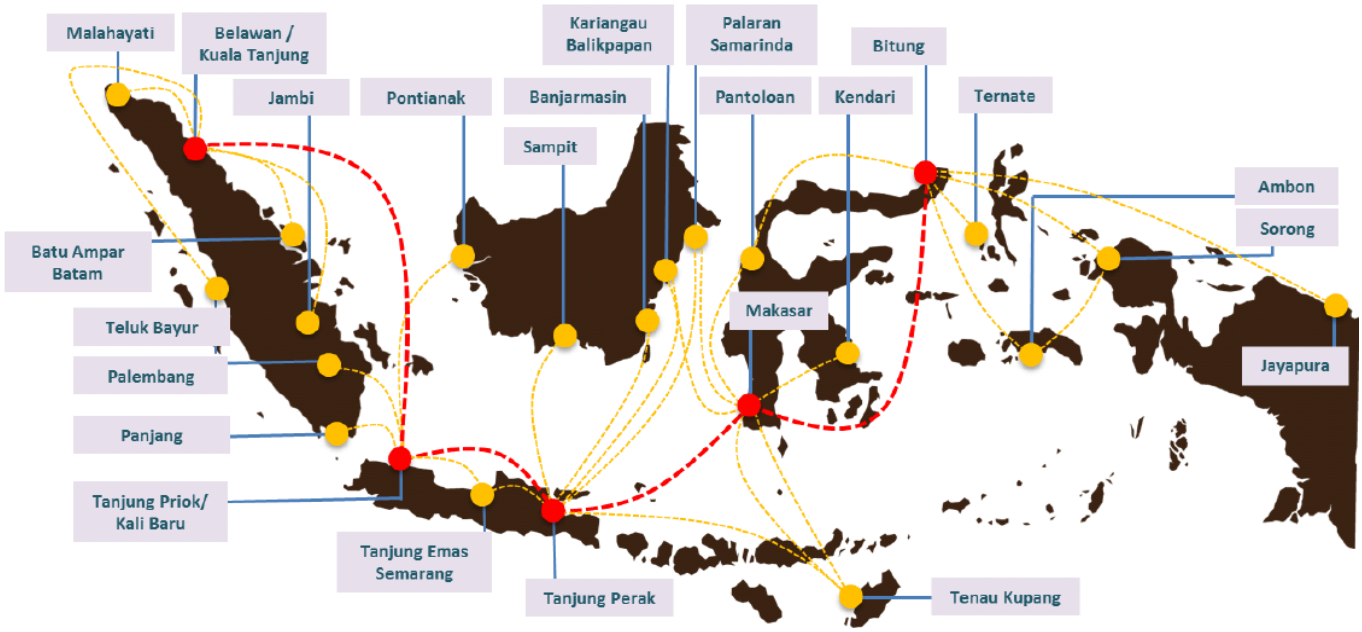

Figure 2: Map of Indonesian Ports and Shipping [14]

Figure 2 presents an overview of the distribution of ports in Indonesia. There are 4 main ports which will be the main gates for exports and imports. Logistics distribution flows, especially for container ships, will involve the main ports and feeder ports spread across the islands of Indonesia. This condition places the logistics flows in Indonesia in a state of multiport activity. Imported commodities that enter from abroad through the main ports will be distributed to national ports. The goods from the national port must also be collected at the main port for the export process. This multiport transport activity occurs within the distribution flow. A good payload arrangement must be planned for smooth operation.

Every ship with its structural characteristics, routes, sequence of ports to be visited and cargo has various complex problems. The existing problems consist of storage plans for a particular set of containers that differ from size, type and weight and for multiple loading ports and destinations. For

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this reason, all containers must be loaded on board, while the structural and operational constraints must be resolved. The main problem which must be resolved is minimizing the time for loading and unloading ships at the port [15]. The shipping container loading must be able to be broken down based on the location and type of cargo, and the size of the container. Figure 2 provides an overview of the containers loaded above the holds and the containers located below the holds [16].

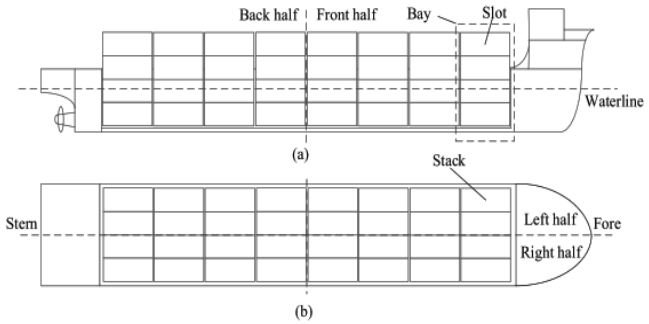

Figure 3: Container Loading Structure

Figure 3 picturizes the container structure when it is loaded in the ship's hold. The containers can be planned for loading in the fore or aft holds. Each loading in the bay needs to have stack space for moving the containers. In the multiport network transportation pattern, the creation of a bay plan by the planner in loading the containers is crucial and must be considered, so that when loading the containers, the re-stowage and unnecessary movements that cause waiting time at the port can be avoided.

Determining the position of containers on the ship can be done by adjusting the ship's route in the multiport transportation network. Prior to the arrival of the ship, the planner receives a list of container loading and expected condition of arrival of the ship which contains details of the containers to be loaded. In many cases, even up to two hours before the loading is complete, the Cargo Loading List (CLL) container loading list is still changing. There may be additional cargo to be loaded, cancellation and changes of the location of containers. Instructions from the charterer to move several containers to other ships as well as to change the shipping route schedule make the planner and Chief Officer change the loading plan, although the loading and unloading activities have been completed. Several containers that have been loaded in the holds must be unloaded to be transferred to other ships. For this reason, there is an impact on the ship departure schedules and timeliness efficiency during the loading and unloading activities.

On the other hand, the chief officer must also consider the preparation, storage, transportation and unloading of cargo to ensure that the ship can operate safely up to the port of destination. The more important thing is to ensure whether the re-stowage process is still in the safe category and in accordance with the Safety Management System (SMS) from the ship's origin company. The time and place when a Re-stowage Cargo Operation occurs must be limited. The cargo operation and re-stowage process flow is presented in Figure 4 below.

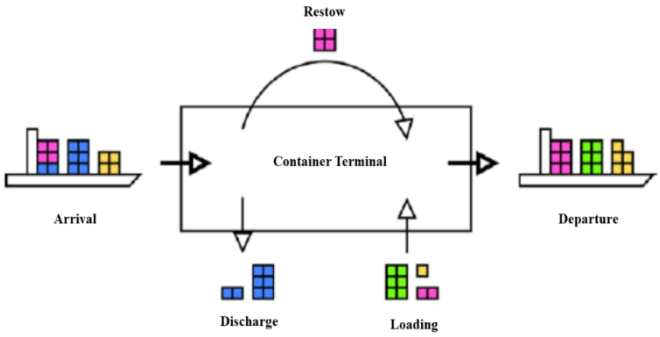

Figure 4: Cargo Operation Container and Re-Stowage

When structuring the container positions, a planner must pay attention to the type of container, container construction, the bay plan and re-checking the bay plan itself. This is done because the weight of the container to be loaded will determine the placement of the container. Determining the container position must not be separated from the ship's ability, so that the container loading can be carried out quickly, regularly and systematically. The flow of a good container arrangement planning is presented in Figure 5 below.

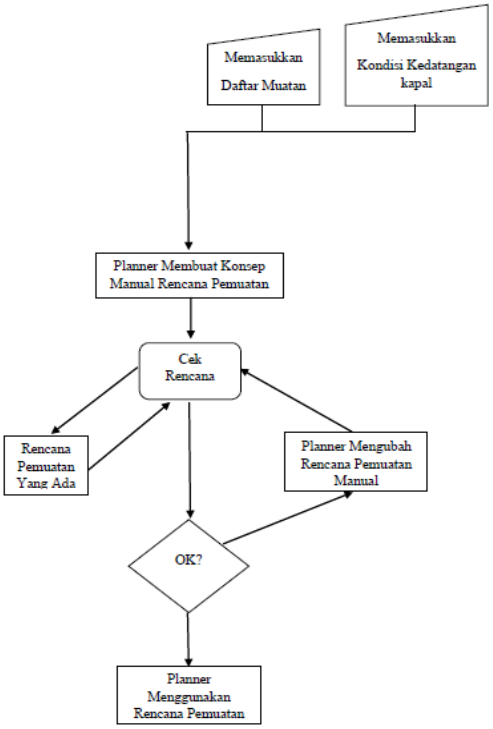

Figure 5: Container Loading Planning Flow

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In adjusting the ship routes for multiport operation patterns, the operation pattern includes ship specifications, ship travel routes, and port development to determine the minimum route in the multiport method. It is recommended that the operations for the multiport pattern do not depend on other ships so that the loading and unloading activities at the port can run according to the existing schedule and the risk of lost or damaged cargo can be avoided. The planners must also have a full understanding of the ship safety during the loading and unloading activities on board. The relationship between the operation conditions and loading plan can be seen in Figure 6 below.

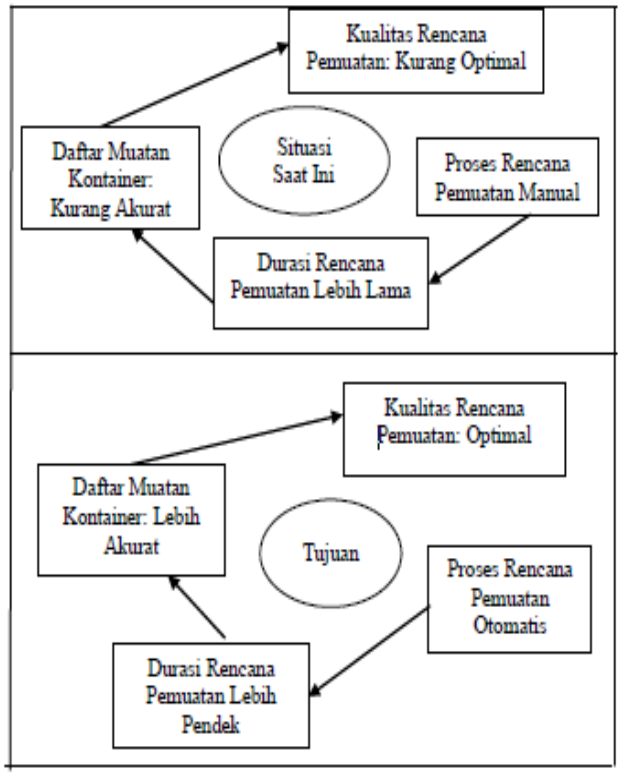

Figure 6: Relationship between Loading Plan and Operation Condition

Efforts to prevent the movement of containers that are not important in the loading and unloading process at the port prevent a longer waiting time. The determination of the container position on board should have been adjusted to the ship's route in the existing multiport transportation network. However, in the existing process, sometimes there is an overhaul or transfer of cargo due to requests by the charterer, so that it brings an impact on the shipping schedules or ship departures and increased time for ships to dock at the port. The synergy between stakeholders greatly influences the success of the loading process and the smooth operation of loading and unloading of the container ships. To realize a safe and efficient container loading and unloading activity, efforts must be made to overcome the obstacles encountered, so that the loading and unloading activities can run well.

The efforts are made by the planners by optimizing the use of Stowage planning software. In addition, the planners also get the information about the state of the ship and its cargo regarding the stability, strength, dangerous cargo, draft, trim and visibility checks. If the use of software is not optimal, it will cause loading planning errors. The efforts to optimize the bay plan can have a positive impact and simultaneously increase the efficiency of loading and unloading time on the ships, and avoid re-stowage which causes delays in the ship departure and additional costs for the ship berths.

In order to optimize the load space, the position of the containers on the ship must be placed in a balanced way so as not to cause harm to the ship and there must be minimized movements or shifts of containers on board that are not important. For this reason, a system that can be used as a plan for placing and moving the containers in a ship (stowage plan) is required. A proper handling of cargo is able to create an efficient and effective process of activities in the use of time and costs, and the goods transported can be in a good condition or not damaged.

Improving a good coordination between the planner and the chief officer involved in the smooth implementation of loading and unloading is important. It benefits the planner and the ship with loading adjustments, starting from the time needed for the cargo loading, up to the cargo unloading. By adjusting the time, the process of loading and unloading the cargo can run well and the ship's departure is as planned. To develop an automatic loading plan, which is then developed by the planner until the loading plan is completed, can reduce the loading planning duration, so that the quality of cargo information will increase, as shown in the figure below. This will improve the quality of the resulting stowage plan.

IV. CONCLUSIONS

The multi-port storage planning problems must consider the entire ship route to generate storage plans for multiple ports across the route. In Indonesia, there are 4 main ports which will be the main gates for the exports and imports. The logistics distribution flows, especially for the container ships, involve the main ports and feeder ports spread across the islands of Indonesia. This condition places the logistics flows in Indonesia in a state of multi-port activity. The existing problems consist of storage plans for a particular set of containers that differ from size, type and weight and for the multiple loading ports and destinations. Therefore, all containers must be loaded on board, while the structural and operational constraints must be resolved. The main problem that must be overcome is that the time for loading and unloading ships at the port which must be minimized.

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